DOCUMENT RESUME

ED 047 974 SE 010 824

AUTHOR Merrill, Paul F.
TITLE The Effects of the Availability of Objectives and/or Rules on the Learning Process.
SPONS AGENCY Department of Defense, Washington, D.C. Advanced Research Projects Agency.
PUB DATE Feb 71
NOTE 22p.; Paper presented at the Annual Meeting of the American Educational Research Association (New York City, New York, February 4-7, 1971)

EDRS PRICE EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS *Behavioral Objectives, *Computer Assisted Instruction, Educational Psychology, *Learning, *Science Education

ABSTRACT

The effects of behavioral objectives and/or rules on the learning process were examined using a hierarchical imaginary science called the Science of Xenograde Systems. The learning task was presented by a computer assisted instruction system to 130 introductory educational psychology and science education students. After being given a battery of six cognitive ability tests, all students were randomly assigned to either an example only, an objective-example, a rule-example or an objective-rule-example treatment. The presentation of rules significantly reduced the number of examples and total time required to complete the task and increased performance on a transfer test. The presentation of objectives did not significantly affect total or display latency, but significantly reduced the requirement for reasoning ability. It was concluded that objectives have orienting and organizing effects which dispose students to attend to, process, and structure relevant information in accordance with the given objectives. (Author/FL)

THE EFFECTS OF THE AVAILABILITY OF OBJECTIVES AND/OR RULES ON THE LEARNING PROCESS

ABSTRACT

Paul F. Merrill
The Florida State University

The effects of behavioral objectives and/or rules on the learning process were investigated using a hierarchical imaginary science called the Science of Xenograde Systems. The learning task was presented by an IBM 1500/1800 computer-assisted instruction system to 130 introductory educational psychology and science education students. After all Ss were given a battery of six cognitive ability tests, they were randomly assigned to either an example only, an objective-example, a rule-example or an objective-rule-example treatment. The Ss were required to meet a minimum criterion performance at each level of the task before proceeding to the next level. The presentation of rules significantly reduced the number of examples and total time required to complete the task and increased performance on a transfer test. The presentation of objectives did not significantly affect total or display latency, but significantly reduced test-item-response latency and the required number of examples. The presentation of objectives and/or rules also significantly reduced the requirement for reasoning ability. On the basis of the results of this study it was concluded that objectives have orienting and organizing effects which dispose students to attend to, process, and structure relevant information in accordance with the given objectives.

THE EFFECTS OF THE AVAILABILITY OF OBJECTIVES AND/OR RULES ON THE LEARNING PROCESS[1,2]

It seems that even though educational psychologists (Bobbitt, 1924; Tyler, 1951; Bloom, 1956) had been stressing the need for precise statements of instructional objectives for many years, it was not until Mager (1961) published his book on preparing objectives that the educational community started to take instructional objectives seriously. Since Mager's book, many people have mounted the bandwagon and filled the literature with articles extolling the virtues of instructional objectives. However, there are those (Eisner, 1967a; Ebel, 1967; Kliebard, 1968; Jackson and Belford, 1965) who question the value of objectives and feel they might actually be a hindrance to the design of instruction. After an interchange of views in the literature, Eisner (1967b) responded to his critics by pointing out that the contribution of educational objectives to curriculum construction, teaching, and learning is an empirical problem, while most articles that have been written are merely logical arguments. He further claims that the little research that has been done is at best inconclusive.

The purpose of this study was to investigate what effects the presentation of behavioral objectives would have on the learning process. Specifically, this study was conducted to further clarify: 1) how the presentation of objectives would affect Ss performance on criteria measures, 2) how other task characteristics would vary the effects of presenting objectives, and 3) how individual aptitudes interact with the presentation or non-presentation of objectives.

It was hypothesized that objectives would serve as orienting stimuli which dispose the student to attend to, process, and organize relevant aspects of displayed information in accordance with the stated objectives. Therefore, the presentation of objectives was expected to reduce the number of examples and amount of time required to learn the task, facilitate performance on transfer retrieval criterion measures, and reduce the requirements for memory and reasoning abilities. However, it was expected that these effects would be tempered by, or interact with other properties of the learning task. If objectives are inserted in a task which has minimal orienting or organizing stimuli, then the above hypothesized effects should be very evident. On the other hand, if objectives are inserted in a task which has other effective orienting stimuli such as rules, then the objectives would be somewhat redundant and have a more subtle effect.

Method

Subjects. The 160 Ss who participated in this study were taken from four sections of an introductory educational psychology course and three sections of a science education course at the University of Texas at Austin. All Ss were required to participate as a class assignment. However, 30 of the original Ss were eliminated because they failed to complete all three phases of the study.

Ability Measures. A battery of six cognitive ability tests was administered to all Ss. The battery consisted of three tests selected from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963) and three task-relevant tests developed for this study. The task-relevant tests required the Ss to process the same type of information that must be processed in the learning task, while the published tests required similar processes on information not related to the task. A list of the individual tests and their factor designations appears in Table 4.

Experimental Tasks and Materials. The learning task used in this study consisted of a hierarchical imaginary science called the Science of Xenograde Systems. The structure and content of the task were similar to those of formal science topics, but the imaginary nature of the science assured that none of the Ss had any previous experience with the task. In the version of the science used for this study, a Xenograde system consists of a nucleus with an orbiting satellite. The satellite is composed of small particles called alphons which also may reside in the nucleus. The subject matter of the science deals with the principles or rules by which the activity of satellites and alphons may be predicted. The terminal objective of the task requires that Ss predict and record the state of the alphons and satellite of a Xenograde system at successive time intervals given the initial state of the system at time zero.

The instructional program consisted of 10 modules. The materials for each module included a statement of a subobjective, a statement of a rule, five examples of the rule, and five short constructed response tests.

The examples were in the form of partial Xenograde tables which showed the activity and relationships of a Xenograde system at several points in time. Samples of these materials may be found in Figure 1.

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Insert Figure 1 about here

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The instructional program was written in the Coursewriter II language and presented to the Ss by the IBM 1500/1800 computer-assisted instruction system.

Procedure. After the administration of the cognitive ability test battery, the Ss were randomly assigned to one of four groups: an example only group (n=32), an objective-example group (n=33), a rule-example group (n=32), or an objective-rule-example group (n=33). Figure 2 is a graphical representation of the 2 x 2 factorial design formed by these groups.

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Insert Figure 2 about here

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In learning the science, Ss in the example only group received an example of the first rule of the science displayed on a cathode ray tube. After studying the example, each S responded to a three-item constructed response test where he was required to predict certain values using the rule inferred from the example. If the S responded correctly to two out of the three test items, he was given an example of the next rule in the sequence. Otherwise, he was given another example of the same rule followed by another three-item test. This sequence of new examples followed by a test continued until the S responded correctly to two of the three test items or received five examples. The task was completed after all 10 rules of the science were learned to the required criterion. A posttest was administered immediately following completion of the learning task, and retention and transfer tests were administered two weeks later.

The Ss in the other three groups learned the science by the same basic procedure except for the following treatment differences. The objective-example group was shown a statement of a subobjective on an image projector while the corresponding example was displayed on a cathode ray tube. The rule-example group was displayed a statement of the rule corresponding to each example, and the objective-rule-example group received both the objective and the rule in addition to the example.

Results

In addition to total scores on the six cognitive ability tests, posttest, retention test, and transfer test mentioned in the previous section, data were obtained for each S on the following criteria: total number of examples required to learn the science, display latency, test-item-response latency, and total latency. Display latency was the total time S spent studying the examples and, depending upon S's treatment group, the corresponding rules and/or objectives. Test-item-response latency was the total time required by S to respond to the three-item tests following each example display. Total latency was merely the sum of the display and test-item-response latencies.

The descriptive statistics and reliabilities of the ability, post, retention, and transfer tests are reported elsewhere (Merrill, 1970).

The treatment effects on the number of examples required to learn the task is graphically portrayed by the group frequency distributions given in Figure 3, while the corresponding means and standard deviations are presented in Table 1. The results from a two-factor analysis of variance revealed a significant rule effect, $F(1,126) = 48.7$, $p < .001$, wherein the presentation of rules reduced the number of examples required to learn the task. A significant objective effect, $F(1,126) = 4.7$, $p < .05$, shows that the presentation of objectives also reduced the number of examples required, but this reduction was not nearly as marked as the reduction caused by the presentation of the rules.

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Insert Figure 3 about here

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Insert Table 1 about here

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The means and standard deviations for each group on the three latency measures may be found in Table 2. The latency measures were also analyzed using a two-factor analysis of variance. A significant rule effect was obtained on all three measures ($F(1,123) = 21.9$, $p < .001$ for display latency; $F(1,126) = 48.8$, $p < .001$ for test-item-response latency; and $F(1, 123) = 39.2$, $p < .001$ for total latency) with the rule groups taking considerably less time to study the displays and respond to the criterion items. The objective effect was significant, $F(1,126) = 12.8$, $p < .001$, only on test-item-response latency with the objective groups requiring less time to respond to the test items than non-objective groups. There also was a significant interaction, $F(1,126) = 4.2$, $p < .05$, with test-item-response latency as criterion. This interaction indicates that the objectives had a greater effect in reducing response latency when added to a task which had no other focusing or organizing stimuli than they did when added to a task which had other effective orienting stimuli such as rules. In other words, the difference in response latency between the example only and objective groups was greater than the corresponding difference between the rule and objective-rule groups.

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Insert Table 2 about here

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Since the experimental procedure required all Ss to perform at a minimum criterion level on each rule before proceeding to the next rule, no group mean differences were expected on the posttest. The confirmation of this expectation made it possible to attribute any group differences on retention or transfer to the differential treatments rather than to differential posttest performance. Even though the rule groups received significantly fewer examples and took significantly less time to learn the task, their performance on the transfer test was significantly higher than that of the no-rule groups ($F(1,126) = 7.8$, $p < .01$). The objective effect did not reach significance at an acceptable level, but it did approach significance, $F(1,126) = 3.1$, $p < .10$, with the objective groups obtaining higher mean transfer scores than the no-objective groups.

However, there were no significant group mean differences on the retention test. The post, retention, and transfer test means and standard deviations may be found in Table 3.

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Insert Table 3 about here

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The battery of cognitive ability tests was factor analyzed, but consistent with previous findings (Bunderson, Olivier, & Merrill, 1971) it was not possible to separate the factors of induction and general reasoning. Therefore, a two-factor varimax solution which yielded the factors of reasoning and associative memory is presented in Table 4. The reasoning factor is marked by the two induction and the two general reasoning tests.

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Insert Table 4 about here

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Regression analyses of the individual ability test scores, factor scores, and the criterion measures were conducted. A significant ability by treatment interaction ($F(3,122) = 3.16$, $p < .05$) was obtained using test-item-response latency as the criterion measure and reasoning factor scores as the covariable. The plot of the regression lines (Figure 4) shows that test-item-response latency has a high negative relationship to reasoning, as defined by the reasoning factor scores, for Ss in the example only group. However, further analysis shows that the corresponding relationship between reasoning factor scores and test-item-response latency is significantly reduced ($F(1,124) = 9.28$, $p < .01$) for Ss in the other three treatments. Similar ability by treatment interactions were obtained using individual reasoning test scores as covariables with test-item-response and total latency as criterion.

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Insert Figure 4 about here

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Discussion

The design of the present study was such that all Ss were required to reach a minimum criterion performance at each level of the task before they were allowed to go on to the next level. This procedure was used to assure that all treatment groups would perform at the same level on the posttest. Unless all groups learned the original task equally well, differential performance on retention or transfer measures could not be interpreted in terms of the organization nor structure provided by instructional treatment. The results confirmed the expectation of non-significant group differences on posttest performance.

Since there was a negligible decrement in performance between the posttest and retention tests for all treatment groups, the retention interval of two weeks may have been too short for the treatments to have had an effect on retention. However, contrary to the learning by discovery hypothesis, the presentation of rules facilitated performance on the transfer task. Even though the rule groups received significantly fewer examples and took significantly less time to learn the task, their performance on the transfer test was significantly higher than that of the no-rule groups. It seems that precisely stated rules have a greater effect on transfer retrieval than objectives. The weak objective effect may have been due to the fact that the objectives only specified that transfer retrieval would be required to solve new problems using previously demonstrated relationships.

An examination of the group frequency distributions with number of examples as criterion shows that the presentation of rules enabled most Ss to learn the science in a minimum number (10) of trials and therefore with nearly zero errors. Objectives had a similar but less pronounced effect. Since the rule treatments brought such a high percentage of Ss to perfect performance in terms of the number of examples required, the full impact of these treatments, using number of examples as criterion, was indeterminate. However, the within group variance was not similarly restricted in the latency criterion measures.

The hypothesis that the presentation of rules would reduce the amount of time required to learn the task was supported by significant rule effects on all three latency measures. The presentation of objectives did not have the hypothesized effect of reducing the total time required to complete the task. This result would seem to contradict the argument that objectives have a focusing effect if it were not for the reduction in the number of examples required by the objective treatments. A comparison of the component latency measures, display and test-item-response latency, revealed that objectives either increased or had no effect on display latency but significantly reduced test-item-response latency. Apparently, the presentation of objectives affected the efficiency and effectiveness of the S's information processing and thereby facilitated his performance on the criterion test items.

The presentation of objectives and/or rules did significantly reduce the relationship between reasoning factor scores and test-item-response latency. Why the treatments interacted with reasoning abilities using test-item-response latency and total latency as criteria and did not interact significantly with display latency and number of examples as criteria is not clear. Apparently, reasoning abilities are more crucial during those stages of the task where Ss respond to the criterion test items.

The hypothesis that objective effects would be greater between the example only and objective groups than between the rule and rule-objective groups was only supported by the significant interaction found with test-item-response latency as criterion. However, an examination of the means for the other criteria shows that the corresponding differences between the means are consistent with the hypothesis. Thus, it is impossible to make broad or general statements about the effect of objectives on the learning process without taking into account the other stimulus properties of the task.

On the basis of the result of this study, it was concluded that objectives have orienting and organizing effects which dispose students to attend to and organize relevant information and thus facilitate performance on criterion-test items constructed in accordance with the objectives. However, these effects are not as pronounced when the learning task contains other orienting stimuli such as rules.

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FOOTNOTES

1. This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by the Office of Naval Research under Contract No. N00014-67-A-0126.

2. Paper presented at the annual meeting of the American Educational Research Association, New York, Feb., 1971.

TABLE 1

Group Means and Standard Deviations of the Number of Examples Required to Learn the Task

OBJECTIVES	RULES			
	NO		YES	
	MEANS	SD	MEANS	SD
NO	15.0	3.6	11.0	2.0
YES	13.3	3.4	10.6	1.2

TABLE 2

Group Means and Standard Deviations for Display Latency, Test-Item-Response Latency, and Total Latency in Seconds

Group	Latency					
	Display		Test-Item-Response		Total	
	Means	SD	Means	SD	Means	SD
Example-Only	821.2	379.8	923.3	430.7	1772.8	771.7
Objective-Example	865.8	377.5	649.3	253.9	1513.5	569.5
Rule-Example	543.9	208.6	493.7	211.7	1037.6	399.1
Objective-Rule-Example	634.3	218.2	419.8	128.2	1053.5	321.2

TABLE 3

Group Means and Standard Deviations for Posttest, Retention Test, and Transfer Test Scores

Group	Posttest		Retention Test		Transfer Test	
	Means	SD	Means	SD	Means	SD
Example Only	45.5	4.9	44.2	7.2	11.0	2.8
Objective-Example	44.3	11.7	43.3	13.9	13.2	4.4
Rule-Example	45.1	12.9	43.6	14.2	14.1	5.9
Objective-Rule-Example	47.8	12.2	46.2	12.2	14.7	5.0

TABLE 4

Varimax Rotation Factor Matrix[a]

TESTS	FACTOR LOADINGS	
	REASONING FACTOR	ASSOCIATIVE MEMORY FACTOR
Memory of Number Series	1877	8336
First and Last Names Test	0078	8465
Bi-Column Number Series	6001	0802
Letter Sets	7006	1954
Tote Mobile	7458	1607
Ship Destination	8191	-1103

[a]Decimal points are omitted.

OBJECTIVE

Given the values of F.F., ACS and the previous distance, predict the value of the next distance.

- -

RULE

The ecrease in distance between each time is equal to the value of F.F. x ACS.

- -

EXAMPLE

F.F. = 2

System Time	ACN	Blip Time	Satellite Distance	ACS
0	5		56	2
1	5		52	2
2	5		48	2
3	5		44	2
4	5		40	2
5	5		36.	2

- -

TEST ITEM

F.F. = 3

System Time	ACN	BLIP Time	Satellite Distance	ACS
0			45	5
1			□	5

What is the value of the distance at time 1? ______________________

Figure 1.--Sample Xenograde Materials

OBJECTIVES	RULES: NO	RULES: YES
NO	EXAMPLE ONLY "X" ($\underline{n}$ = 32)	RULE EXAMPLE "R" ($\underline{n}$ = 32)
YES	OBJECTIVE EXAMPLE "O" ($\underline{n}$ = 33)	OBJECTIVE RULE EXAMPLE "RO" ($\underline{n}$ = 33)

Figure 2.--2 x 2 factorial design used in this study

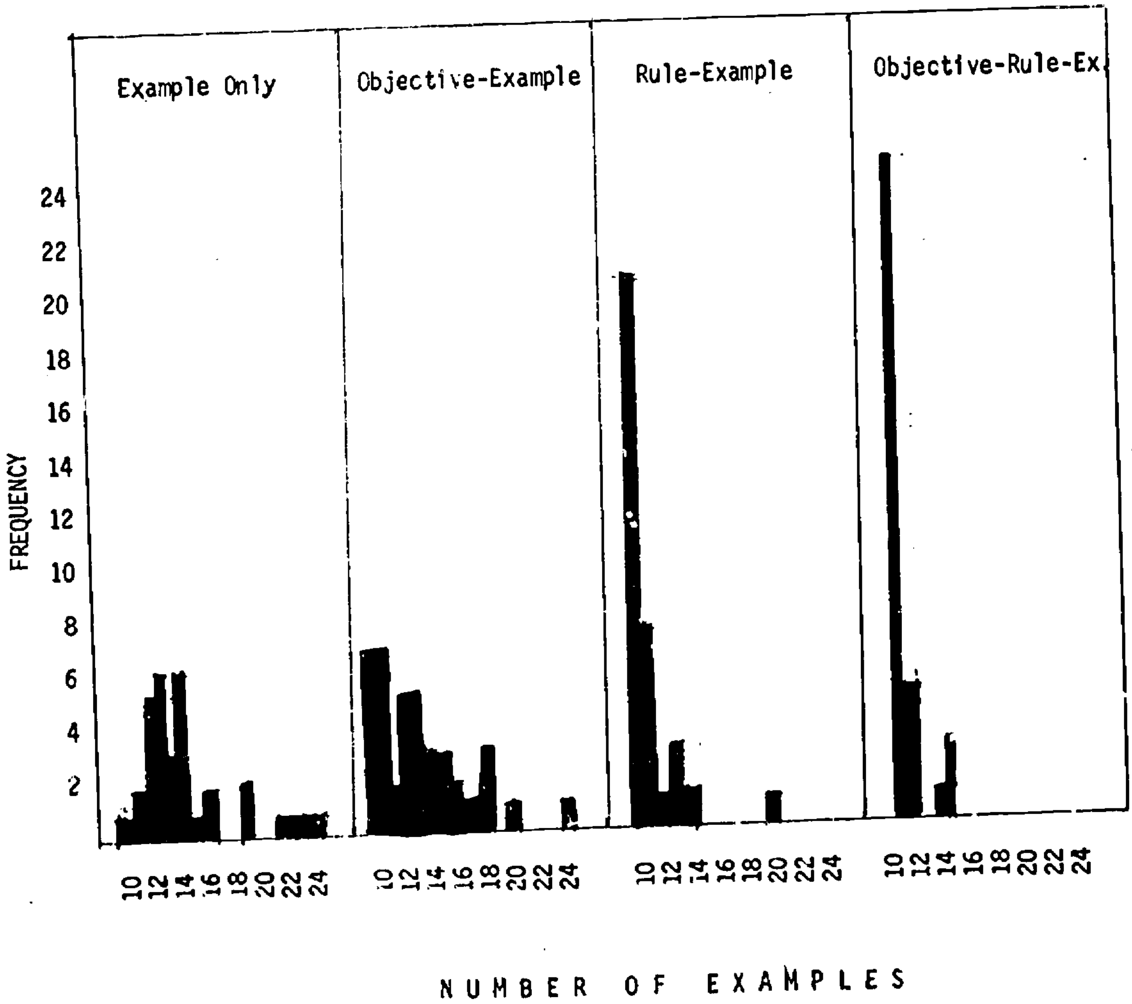

Figure 3.--Frequency Distribution by Treatment Group of the Number of Examples Received

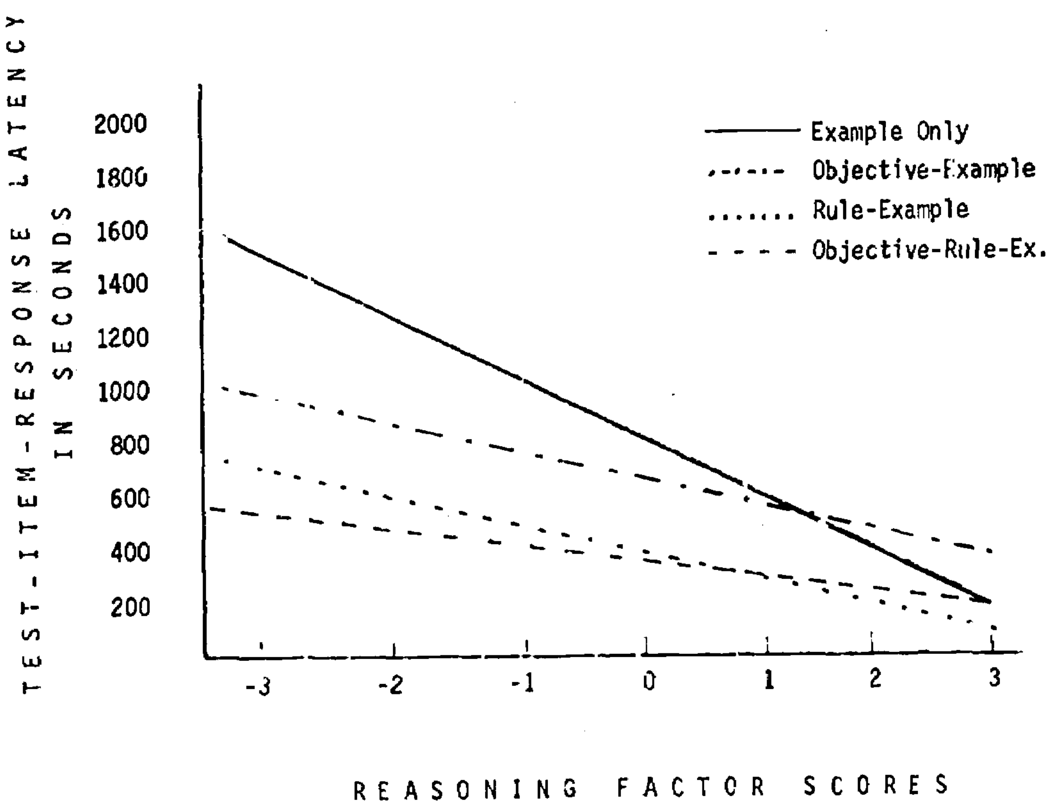

Figure 4.--Interaction of Reasoning Factor Scores and Treatments with Test-Item-Response Latency as Criterion